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EMERGING ENGINEERING TECHNOLOGIES

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14-article report on pulping, bleaching, papermaking, and process control advances

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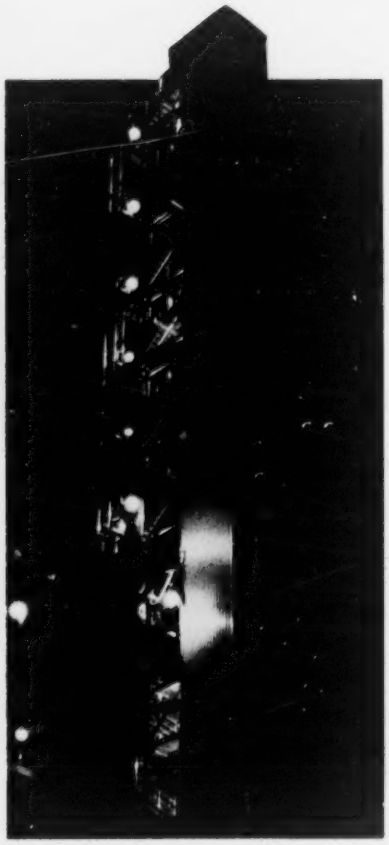

THE COVER

The September issue is a special report on emerging engineering technologies—a comprehensive look at new pulping and papermaking processes that will shape the industry as it enters the twenty-first century. The report examines technologies currently in the pilot-plant stage or just being implemented (nonchlorine bleaching systems, artificial intelligence, biopulping/biobleaching), as well as developing technologies expected to become commonplace in the next several decades. A special thanks to Alabama River Pulp Co. for allowing P&P editors to photograph their mill in the dead of night. (Staff photo by Kelly H. Ferguson.)

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ABP

BPA

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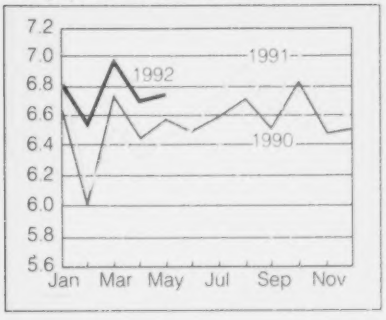
U.S. paper and board production



U.S. production of paper and paperboard totaled 6.7 million tons in May, up 3.4% from the same month last year, according to the American Paper Institute. The seasonally adjusted production rate stood at 41.6 million tpy for paperboard, up 5.6% from a year earlier, and 39.3 million tpy for paper, up 2.3%. May production was down a seasonally adjusted 2.0% from the previous month, however, reflecting the slowdown in the general economy.

Among the major grades, printing and writing paper shipments were up 2.5% from year-earlier levels through the first five months, but the trend rate for May was off by 2.6% following a 1.9% decline in April. Newsprint production remained strong, posting a 4.0% increase over last year. Containerboard production for domestic use showed a 7.9% gain through May, but production for the export market was up just 1.1%. Market pulp shipments have risen sharply in 1992, up 12.3% through May compared with last year. Anticipation of the strike in British Columbia that began in mid-June contributed to the increase.

Canadian newsprint shipments totaled 815,000 metric tons in May, up 13.7% from a year earlier, according to the Canadian Pulp & Paper Assn. Operating rates rose to 96%. Woodpulp mills operated at 82%, and shipments rose 5.7% for the month to 737,000 tons. ■

	Latest month (000 short tons)		% change from year ago	Annualized year-to-date (000 short tons)	% change from year ago
PAPER & PAPERBOARD PRODUCTION[1]					
Newsprint	May	584	1.7	7,043	4.0
Uncoated groundwood (s)	May	127	-9.3	1,508	-12.4
Coated paper (s)	May	583	1.9	7,165	2.4
Uncoated free-sheet (s)	May	929	-2.9	11,684	5.3
Other printing/writing	May	121	-1.6	1,484	N/A
Total packaging and other paper (s)	May	378	3.0	4,697	2.0
Tissue	May	480	1.7	5,752	-0.1
Total paper	**May**	**3,198**	**-0.2**	**39,332**	**2.3**
Unbleached kraft paperboard	May	1,795	7.4	21,723	7.4
Semichemical medium	May	517	9.5	5,970	5.6
Bleached paperboard	May	381	-3.1	4,518	-1.8
Recycled paperboard	May	813	9.3	9,623	7.7
Total paperboard	**May**	**3,506**	**6.9**	**41,834**	**6.1**
Total U.S. paper and paperboard output	**May**	**6,704**	**3.4**	**81,166**	**4.2**
PULP, WASTEPAPER & FIBER[2]					
Total U.S. woodpulp production	May	5,326	2.7	65,463	3.3
Market pulp production	May	805	13.4	10,012	11.3
Wastepaper consumption at paper/board mills	May	2,076	17.8	24,320	10.8
Pulpwood consumption (cords)	Apr.	8,411	1.7	99,414	-0.6
CONVERTED PRODUCTS STATISTICS[3]					
Corrugated box shipments (billion ft²)	June	28.368	10.3	166.606[6]	6.3
Containerboard inventories at U.S. box plants and mills	May 31	2,960	14.7		
INTERNATIONAL TRADE[2]					
U.S. paper imports (including products)	Apr.	987	-1.0	11,563	-6.0
Imports of Canadian newsprint	Apr.	576	-7.2	6,675[6]	-13.6
U.S. paper exports (including products)	Apr.	747	9.4	8,817	9.0
Exports of unbleached kraft linerboard	Apr.	275	16.5	3,153	3.3
Exports of woodpulp	May	646	12.2	7,556	18.1
Norscan pulp inventories[4]	May 31	1,275	-19.5		
Norscan pulp operating rates[4]	May	86%	92%	95%	93%
CANADIAN STATISTICS[5] *(reported in metric tons)*					
Total newsprint shipments	May	815	13.7	3,612[6]	-1.7
Operating rates	May	96%	87%	87%	91%
Inventories held by U.S. consumers	May 31	N.A.			
Other paper/board shipments	May	625	-2.6	3,170	4.5
Woodpulp shipments (export only)	May	737	5.7	3,864	11.7
Operating rates	May	82%	87%	89%	90%

1. American Paper Institute. 2. API, Bureau of Census, American Pulpwood Assn. 3. Fibre Box Assn, Paperboard Packaging Council. 4. North American/Scandinavian paper-grade market pulp. 5. Canadian Pulp & Paper Assn. 6. Not annualized. (s) = Shipments.

Uncoated groundwood: SC demand is bright spot in weak markets

Grade structure: Specialty newsprint grades (such as smooth or high-brightness news) are continuing to replace the low end of the uncoated groundwood grade scale (primarily rotogravure newsprint). At the same time, more and more mills move into machine-finished (MF), supercalendered (SC), and soft calendered grades at the higher end. There is a strong move toward converting older, less competitive newsprint machines to directory paper, a much higher-valued uncoated groundwood.

In general, uncoated groundwood papers have higher brightness levels and smoother surfaces than newsprint. Supercalendering and soft calendering add a glossy surface often competing with lightweight coated (LWC) groundwood papers. Brightness levels range from 64 to 74 Elrepho, compared to 56 to 62 for standard newsprint and 68 to 84 for LWC. Basis weights range from 20 to 45 lb/3,300 ft^2. Primary uses include preprinted newspaper inserts and direct mail flyers, catalogs, lower-cost business forms, Sunday newspaper magazines, and telephone directories.

Production/capacity: About 1.775 million tons of uncoated groundwood papers were shipped by U.S. mills in 1991, down 1.7% from 1990 because of the weak economy and cheaper prices for competing grades. Canadian mills shipped about 1.993 million short tons, a slight advance (2.0%) from 1990.

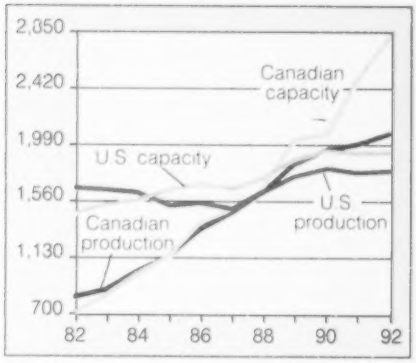
As the newsprint industry continues to suffer from overcapacity, inefficient equipment, and market factors, mills that have not shut down machines are planning to convert some to uncoated or coated groundwood. For example, Bowater Inc. plans to convert newsprint machines at the former Great Northern Nekoosa mills in Maine to higher-value groundwood or coated groundwood grades. In addition, both St. Marys Paper Inc. and Stone-Consolidated Inc. have built new SC machines at their mills in Sault Ste. Marie, Ont., and Grand-Mère, Que., respectively. However, Canadian Pacific Forest products shut down its Trois Rivières, Que., newsprint and groundwood papers mills in April 1992 because the inefficient mill could not make it in weak markets.

The closing of Trois Rivières is not taken into account in the following capacity figures: Canadian uncoated groundwood capacity is expected to increase 16.3% in the 1991-94 period, rising from 2.497 million short tons in 1991 to 2.905 million tpy. U.S. capacity is projected to increase only slightly, from 1.923 million tons in 1991 to 1.934 million tpy in 1994.

Outlook: Demand for uncoated groundwood papers is now estimated to rise 2.2% for 1992, with a strong 7.2% advance in 1993 and another healthy 4.8% in 1994. New capacity from European mills adds to the availability of SC papers and possibly keeps pricing at a level that makes the grade attractive to users of both lower-end grades and LWC papers.

Transaction prices (year-end, except 1992) for 34-lb premium supercalendered ($/short ton) are: 1989, $830; 1990, $800; 1991, $800; mid-year 1992, $760. Prices for 35-lb offset, 65 brightness are: 1989, $635; 1990, $635; 1991, $610; mid-year 1992, $600. ■

SUPPLY/DEMAND (000 tons)



FORECAST (000 tons)

U.S.	1990r	1991r	1992e
Production	1,806	1,775	1,788
Capacity[1]	1,946	1,923	1,930
Utilization rate	92.8%	92.3%	92.6%
Imports	1,338	1,369	1,450
Exports	75	117	115
Apparent U.S. consumption	3,069	3,027	3,123
lb/capita	24.55	23.96	24.54
GDP ratio[3]	0.63	0.62	0.63
Canada[2]			
Production	1,954	1,993	2,076
Capacity	2,072	2,497	2,855
Exports	1,705	1,790	1,640
Utilization rate	94.3%	79.8%	72.7%

e = *Pulp & Paper* estimate. r = Revised.
1. American Paper Institute. 2. Canadian Pulp & Paper Assn. 3. 1,000 tons/$ billion real GDP (1987).

TOP NORTH AMERICAN PRODUCERS

	Annual capacity (000 tons)	Market share (%)
1. Abitibi-Price Corp.	500	10.5
2. Stone-Consolidated Inc.	480	10.1
3. MacMillan Bloedel Inc.[1]	460	9.7
4. Bowater Inc.	320	6.7
5. Champion International	297	6.2
6. Boise Cascade Corp.	285	6.0
7. St. Marys Paper Inc.	270	5.7
8. Lake Superior Paper	240	5.0
9. Kruger Inc.	237	5.0
10. Madison Paper Industries[2]	222	4.7

Market share of top five companies: **43.2%**

Market share of top ten companies: **64.9%**

North American capacity (1992): **4,757 million short tons**

U.S.: **1,930** Canada: **2,827**

1. Units of Noranda Forest Inc. Total Noranda capacity is 744,000 tons. 2. Includes 20% capacity increase online June 1992.

SALES AND EARNINGS

Second period is first upturn in three years

A recent *Pulp & Paper Week* survey of 29 U.S. forest products companies showed second-quarter earnings of $647 million, an increase of 5.2% compared with the same period in 1991 and the first year-to-year gain in profits in three years. Earnings advanced for the three months ending June 30, 1992 due to strength in wood products, improvement in the brown packaging grades, and reduced overhead costs as companies benefited from recent restructuring efforts. White paper grades and newsprint, however, continued to be very weak. Sales for the 29 companies surveyed were $24.2 billion, up 5.0% relative to second-quarter 1991.

Though prices for certain lumber products fell from the highs reached in the first quarter of the year, earnings for the wood products sector continued to be very strong. Based on a sample of 10 companies that break out the performance of their wood products/building products segments, operating profits in the second quarter for this sector were up 40% year to year and 5% higher than in the first three months of 1992. Weyerhaeuser Co. and Georgia-Pacific Corp. were among the beneficiaries of strength in wood products. Weyco appears to also be reaping benefits from its recent restructuring efforts, most notably at its wood products manufacturing and distribution and containerboard packaging and pulp manufacturing segments, the company said. Louisiana-Pacific Corp., which generates about 90% of its revenues from building products, boasted one of the industry's strongest profit advances, attributing it to "strong markets for its construction panels and recovery of its Southern mills, where production had been sharply curtailed during the first quarter."

Among the larger, more diversified companies, International Paper Co. earned $114 million, comparing favorably with adjusted earnings in both second-quarter 1991 ($100 million) and first-quarter 1992 ($104 million). The profit advance was driven by strong and/or improved performances at the company's timber and wood products, consumer packaging, and specialty businesses, as well as cost controls, lower interest expense, and interest income from a tax settlement. IP did note, however, that the prices for uncoated printing and writing papers in the U.S. and European markets had weakened as the June quarter progressed.

Despite high marketing expenses, Kimberly-Clark Corp. reported that net income rose to $138.2 million, up approximately 12% year to year. Major reasons for the improvement included higher sales volume, operating efficiencies at many of the company's U.S. manufacturing facilities, and lower raw material costs. In addition, K-C recovered an unspecified amount of legal fees related to the settlement of diaper litigation with Procter & Gamble Co.

Companies geared to printing and writing papers and/or newsprint continued to flounder in second-quarter 1992. Boise Cascade Corp. posted a significant net loss, largely due to an operating deficit suffered at its paper and paper products operations and high interest expense. At Bowater Inc., the bottom line continued to slide to new lows as its pulp and paper segment reported an operating deficit equivalent to a $33 loss for every ton of pulp and paper shipped. And it may be a while before results pick up meaningfully. At Champion International Corp., lower prices for newsprint and publication papers overshadowed a stellar performance by its wood products group as the company booked a $9-million net loss, not including a roughly $13-million gain related to the sale of timberland. ■

U.S. paper/products industry results.

	Second-quarter 1992 ($000)			
Companies	**Sales 1992**	**% change 1992/91**	**Earnings 1992**	**% change 1992/91**
Boise Cascade Corp.	$922,200	−0.1%	($44,970)	NM
Bowater Inc.	355,947	9.1	(24,416)	NM
Champion International Corp.[1]	1,229,570	4.3	(8,799)	NM
Chesapeake Corp.	229,294	4.8	4,293	76.6
Consolidated Papers Inc.	221,688	0.3	15,133	−38.4
Federal Paperboard Co. Inc.	345,300	−0.8	25,500	−5.3
Fort Howard Corp.	281,635	−3.9	(12,518)	NM
Georgia-Pacific Corp.	3,046,000	2.2	0	NM
P.H. Glatfelter Co.	138,913	2.8	15,447	−11.9
International Paper Co.[1]	3,386,00	8.7	114,000	14.0
James River Corp.	1,236,625	5.8	15,587	−31.2
Kimberly-Clark Corp.	1,748,600	3.6	138,100	12.1
Longview Fibre Co. (4/92)	172,868	9.3	9,679	195.2
Louisiana-Pacific Corp.[1]	539,100	11.2	48,100	64.7
Mead Corp.[1]	1,225,400	4.2	41,900	124.1
Mosinee Paper Corp.	57,551	23.9	877	NM
Pentair Inc.	296,735	4.5	8,180	−7.9
Pope & Talbot Inc.	129,764	−0.7	(2,623)	NM
Potlatch Corp.	328,399	3.7	20,034	70.2
Riverwood International Corp.	282,200	9.7	13,900	−0.7
Scott Paper Co.[1]	1,221,200	6.5	46,600	52.8
Sonoco Products Co.	461,573	9.3	29,578	32.1
Stone Container Corp.	1,371,100	3.3	(41,200)	NM
Temple Inland Inc.	523,500	7.8	47,700	17.5
Union Camp Corp.	778,790	6.6	22,729	−23.9
Wausau Paper Mills Co. (5/92)	94,957	7.6	10,667	29.3
Westvaco Corp. (4/92)[1]	593,422	6.4	36,414	19.3
Weyerhaeuser Co.	2,349,032	2.3	92,904	44.0
Willamette Industries Inc.	592,129	19.7	24,533	112.1
Totals	**$24,159,492**	**5.0%**	**$647,329**	**5.2%**

1 Excludes major nonrecurring items.
( ) = losses. NM = not meaningful.

CAPITAL SPENDING

U.S. paper companies plan to trim capital spending by 2.8% in 1992

U.S. paper companies have been increasing their capital spending plans despite weak market conditions and depressed profits. According to a recent Commerce Dept. survey conducted in April and May, U.S. companies now plan to spend $11.3 billion in 1992, down 2.8% from 1991 outlays of $11.63 billion. However, this was up 5.0% from the previous Commerce Dept. survey conducted in the first quarter. A tabulation of capital spending plans for 11 major U.S. pulp and paper companies culled from recent annual reports and company statements also shows spending will be relatively flat in 1992.

Spending by Canadian paper companies shows a similar mixed pattern, with environmental projects related to dioxin reduction and deinking installations helping keep outlays up despite recent substantial financial losses. ■

North American paper company capital spending plans ($ millions).

	1990	1991	1992e	% change 1992/91
U.S.				
Bowater Inc.	$214	$160	$135	−15.6%
Champion International Corp.	926	575	625	8.7
Georgia-Pacific Corp.	866	528	500	−5.3
International Paper Co.	1,267	1,197	1,200	0.3
James River Corp.	457	467	467[1]	0.0
Mead Corp.	490	274	300	9.5
Potlatch Corp.	318	267	223	−16.5
Scott Paper Co.	815	315	450[1]	42.9
Union Camp Corp.	934	483	250	−48.2
Westvaco Corp.	487	303	360	18.8
Weyerhaeuser Co.	928	663	750	13.1
Canada				
Abitibi-Price Inc.	C$106	C$39	C$50	28.2
CP Forest Products Ltd.	426	350	300	−16.7
MacMillan Bloedel Ltd.	367	241	300	24.5
Fletcher Challenge Ltd.	248	176	70	−60.2

e = estimate. Source: Company annual reports, releases.
1. Estimate based on company statement.

RECYCLED NEWSPRINT

Federal recycling law defies opposition

The House Energy and Commerce Committee defied opposition from an unlikely coalition of environmentalists and the Bush Administration in approving a solid-waste disposal bill July 3, sending the measure to the floor of the House of Representatives for a vote.

The bill is seeking to make packaging producers reduce the amount of virgin material they use and also will require newspapers above 200,000 circulation to meet annual recycled-fiber-content standards of 35% by 1995 and 50% by 2002, far higher than the 16% aggregate average recycled content of most newspapers today. This area of the legislation is stirring opposition by both newspaper and newsprint industry forces, who are joining the government and environmental forces already opposing the bill but with contradictory motivations. The Bush Administration opposes the bill because it is too costly and environmentalists because it is too weak.

Newspaper sources said the legislation will push up newsprint prices and tie up recycled-content newsprint supplies for large customers, making it harder for smaller newspapers to acquire recycled in order to comply with existing state laws. Violators of the law will be fined $25 for each ton that does not meet the new standards and be required to display a statement on mastheads stating they do not meet recycled requirements. Advertising competitors such as catalogs and Yellow Pages will not be forced to give up lower-cost virgin paper, newspaper industry representatives argue.

Federal mandates will add costs to newspapers and newsprint producers alike, observers said, harming Canadian mills that are distant from sources of old newspaper (ONP) as well as interfering with the development of new uses for ONP, such as in the areas of insulation and animal bedding.

Both of the bill's sponsors, committee chairman Representative John Dingell (D-Mich.) and Representative Norman Lent (R-N.Y.), shored up support for the solid waste bill by agreeing that neither would support new amendments proposed for debate unless they were supported by the other. Dingell authored the newsprint area of the legislation, reacting to a glut of ONP that is not being consumed and which has kept wastepaper prices low.

"This establishes the principle that the polluter pays," said an Energy and Commerce Committee spokesman, adding that, despite a decline in recent years, ONP remains the single largest contributor to the solid waste stream. Dingell said that only six daily newspapers would currently meet the proposed standards, but paper industry sources countered that four of them enjoyed equity in recycled newsprint mills, which enhanced their ability to achieve high recycled-content levels.

"Unfortunately, there was no recognition that the newspapers of this country, in a very short time, have written a recycling record we can all view with pride," stated Newspaper Assn. of America (NAA) president Cathleen Black. "This amendment is a flat reversal of the carrot and stick approach. Unfortunately, it sends a clear message to other industries that voluntary recycling efforts not only will go unrecognized, they will actually be penalized." ■

U.S. Nonwood Fiber Potential Rises as Wood Costs Escalate

Modern technologies in harvesting, handling, and pulping nonwood fibers could restore former papermaking importance

By JOSEPH E. ATCHISON

When considering a greater use of nonwood plant fibers in the U.S., it should be remembered that straw and cotton rags were used here as papermaking raw materials before wood was used. Furthermore, at one time practically all corrugating medium was produced from straw, and the quality was excellent.

However, because the economics of pulp production have favored wood in the U.S., production and use of nonwood plant fiber pulps declined over the past 30 years; therefore, during 1991, total production of nonwood plant fiber pulp in the U.S. amounted to about 240,000 metric tons out of a worldwide total pulp production in excess of 57 million metric tons. This tonnage consisted mainly of pulp for specialty papers, including cotton fiber for currency and other specialty papers, cotton linters and flax straw for cigarette paper, bagasse for insulating board, and abaca (manila hemp) and other specialty fiber pulps for tea bags, filter papers, sausage casings, etc.—all of which sell at a very high price.

In contrast to the decrease of these straws as raw materials in the U.S., the worldwide increase in production capacity of nonwood plant fiber pulps has increased dramatically in the past 15 years, going from 6.9% of total world papermaking pulp capacity in 1975 to 8.5% in 1990. It is projected that this percentage will increase to as much as 10% by 1995. The average annual increase in nonwood plant fibers pulping capacity has been appreciably higher than the average annual increase in wood pulping capacity, and it is projected to be two to three times the average increase in wood pulp capacity during the 1990-95 period.

For quality reasons, straw, bagasse, and bamboo are the leading fibers being used, but many other nonwood plant fibers are being used for specialty pulps. In many countries, pulp production is based entirely on nonwood fibers, and 21 countries—led by China and India—depend on nonwood plant fibers for more than 50% of pulp production.

A proper blend of nonwood plant fibers can produce most grades of paper and paperboard. However, the logical development in the U.S. would appear to be merely adding a nonwood fiber line to a pulp and paper mill with an existing chemical recovery system.

Surprisingly, modern technology for production of pulp from nonwood plant fibers was developed primarily in the U.S. It was based on extensive research and development programs on bagasse pulping, which started in the 1950s and continue in both the U.S. and other major sugarcane-producing countries today. Although used only to a limited extent in the U.S., this technology has spread worldwide and has laid the foundation for the modern bagasse pulping industry.

Fortunately, the technology that was developed for bagasse can be applied to other nonwood fibers as well and is being applied to straw, bamboo, reeds, grasses, cotton linters, and other raw materials worldwide. Although the economics of U.S. pulp production in the recent past have favored wood, it is thought that as pulpwood costs continue to rise, the time is approaching—at least in some areas of the U.S.—when some of these alternative fibers will again become economical and will be used to a greater extent.

What then are the alternative raw materials that hold the best promise in the U.S.? For the medium to long term, it is believed that the most promising nonwood plant fibers for use on a reasonably large scale are as follows:

- Sugarcane bagasse
- Cereal straws including wheat, rye, barley, oats, and rice
- Seed-grass straw
- Grain sorghum stalks
- Kenaf and crotalaria.

Table 1 shows the potential availability of nonwood plant fibers as raw materials in the U.S. Some brief comments on each of these alternative fibers follow.

BAGASSE. When considering the use of bagasse, an important factor is the cost of replacement fossil fuel to generate the necessary steam and power for the sugar

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Table 1: **Estimated availability of specific nonwood plant fibrous raw materials in the U.S.**

Raw materials	Potential availability in the U.S. (b.d. metric tons)
Sugarcane bagasse	4,680,000
Wheat straw	72,000,000
Barley straw	6,000,000
Oat straw	10,000,000
Rye straw	800,000
Rice straw	2,500,000
Seed flax straw	500,000
Seed grass straw	1,000,000
Subtotal straw	**92,800,000**
Total cotton staple fiber	3,100,000
Total first- and second-cut linters	460,000
Cotton stalks	4,600,000
Corn stalks	129,000,000
Sorghum stalks	28,000,000
Kenaf and crotalaria bast fibers	N.A.[1]
Total	**262,640,000**

1. Unlimited quantities can be grown.

mill operation. Therefore, the equivalent heating value in replacement fuel must be furnished for whatever bagasse is taken away.

Normally, however, the moist depithing of the bagasse--at 50% moisture content—is carried out at the sugar mill and the pith returned to the sugar mill boiler. Thus, the pulp mill furnishes replacement fuel for only the moist depithed bagasse, plus the cost of moist depithing and a small premium payment above the actual cost of fuel.

The amount of bagasse available in the various cane sugar-producing areas and the moist depithed bagasse that might be obtained from the sugar mills, plus the potential bleached pulp and/or the potential semiedium, are shown in Table 2.

Bagasse could come into play as a supplementary pulp, especially in pulp and paper mills located in Louisiana and Texas, by merely adding a bagasse pulping line to an existing pulp mill, or to an existing particleboard or medium-density fiberboard (MDF) plant. The bleached pulp could supplement bleached hardwood pulp, the semichemical pulp could supplement hardwood semichemical pulp, and chemimechanical bagasse pulp could supplement mechanical woodpulp for newsprint. Well-prepared bagasse is also excellent for particleboard or MDF. Greenfield bagasse-based mills might also be considered for corrugating medium or MDF in any of the cane sugar-producing states, including Louisiana, Florida, Texas, and Hawaii.

CEREAL STRAWS. As shown in Table 1, total cereal straw in the U.S., including straw from wheat, rice, rye, oats, and barley, amounts to more than 90 million metric tons, or more than 100 million short tons. Fairly substantial amounts of some types of cereal straw are available in almost all of the lower 48 states, with large quantities available in many of the major pulp- and paper-producing states. Wheat straw is the most commonly used cereal straw for manufacture of pulp, and more than 80 million tons are available in the U.S. However, straw from rye, barley, oats, and rice is also being used to a limited extent in other countries.

All corrugating medium in the U.S. was once produced from straw in the Midwest, and at one time both Mead Corp. and Alton Boxboard had small bleached straw pulp mills as well. In fact, as many as 25 Midwestern mills produced high-quality straw corrugating medium as recently as World War II. These mills were using inefficient methods of collection, baling, and storage, and the old rotary batch globe digester had four-hour cooking cycles; therefore, as labor costs escalated, these mills either modernized and switched to hardwoods or went out of business.

However, the adoption of modern technology for collection, baling, and handling straw, combined with the high-yield horizontal continuous digester (using a screw feeder for a quick cook of 10 to 12 minutes), would drastically change the entire economics of straw utilization in the U.S. It is foreseen that straw use will make a comeback, especially for such grades as corrugating medium.

SEED-GRASS STRAW. The straw residue from growing grass for seed is also a potentially attractive supplementary raw material. In the Willamette Valley of Oregon alone, more than one million tons of straw residues from seed-grass production are burned annually.

Table 2: **Total U.S. annual bagasse production and potential yields of bleached pulp and high-yield pulp by state.**

State	Total whole bagasse produced (b.d. short tons)	Potential moist depithed bagasse	Potential bleached pulp	Potential high-yield pulp
Florida	1,800,000	1,080,000	432,000	648,000
Louisiana	1,200,000	720,000	288,000	432,000
Hawaii	1,300,000	780,000	312,000	468,000
Puerto Rico	200,000	120,000	48,000	72,000
Texas	180,000	108,000	43,000	65,000
Total	**4,680,000**	**2,808,000**	**1,123,000**	**1,685,000**

The straw from annual rye-grass, which represents the largest single seed-grass crop, has been thoroughly investigated by Oregon State Univ., and results indicate that pulp produced from this straw is equally as good as pulp from wheat straw. Therefore, this raw material could serve as a supplementary raw material for hardwood pulps in that general area, either for bleached grades or for corrugating medium, or even for linerboard in percentages up to 25%.

The large seed-grass growers already have storage sheds in which the straw could be stored and brought into the mill as required, so the pulp mills would not have to store large quantities of the straw. Thus this raw material appears to be particularly attractive for consideration by mills in the area of the Willamette Valley.

GRAIN HARVEST STALKS. It is estimated that as much as 28 million tons of grain sorghum stalks are available annually in the U.S. in some 20 states, with the largest concentration in Kansas and Texas. All the technology developed for bagasse and straw can likewise be used for collection, preparation, handling, storage, and pulping sorghum stalks, especially for use in the production of corrugating medium. The large quantities of these stalks in concentrated areas make the use of this raw material particularly attractive.

THE SPECIAL CASE OF KENAF AND CROTALARIA. For the past 25 years, the USDA has been making concentrated efforts to develop the use of kenaf. Studies have involved both growing and pulping this raw material. Kenaf was selected from more than a thousand possible crops as having the greatest potential as a new fiber crop that would not compete with agricultural crops now in surplus supply. The USDA also investigated crotalaria, or sunn hemp, which likewise has good potential.

In addition to the work in the U.S., where a number of private companies have been making concentrated efforts to commercialize the use of kenaf in recent years, extensive work on the use of kenaf has been carried out in Australia, China, India, Thailand, and many other countries. Therefore, kenaf and crotalaria appear to hold considerable promise as papermaking raw materials.

Both kenaf and crotalaria consist of two distinctive components which differ both physically and chemically. The bark, or outside of the stem, contains the bast fibers that have a relatively long length. This material makes excellent long-fiber pulp, superior to most softwood pulps. It can also be used as a component of specialty pulps such as for cigarette paper. The bark represents 30% to 35% of the dry weight of the kenaf stalk.

The inside of the stalk, or core, represents 65% to 70% of the dry weight but has an extremely short fiber length of about 0.6 mm. Therefore, it is not suitable for chemical pulp but can be used for production of mechanical pulp and for many other purposes.

Extensive work on the use of whole-stalk kenaf for newsprint has been carried out in the U.S. over the past 10 years, financed heavily by the USDA and fully supported by The American Newspaper Publishers Assn. and several individual publishers. Several full-scale test runs have been carried out on commercial newsprint machines in which varying percentages of whole-stalk kenaf chemi-thermomechanical pulp have been blended into the newsprint furnish, with up to 90% of this pulp being used successfully.

The resulting newsprint has been printed by various publishers and has been found to fully meet North American standards for newsprint. Unfortunately, in spite of well-financed promotion, these efforts with whole-stalk kenaf have not been successful in developing a full-scale kenaf newsprint mill in Texas.

Conversely, intensive work has been carried out on developing efficient techniques to separate the bark (containing the bast fiber) and the short-fibered core material. By separating these two components of kenaf or crotalaria, pulping the bark, and using the core material for purposes to which it is more suited, a number of interesting possibilities are presented. The bark fiber results in an extremely high-quality pulp that can be used in some high-priced specialty papers, whereas the core material has possibilities for mechanical pulp, as fuel, or for a number of other uses based on its absorbency and biodegradability.

Already, there are at least three small commercial separation plants in operation that are capable of handling either kenaf or crotalaria: Mississippi Delta Fiber Cooperative in Charleston, Miss., (*P&P*, July 1992, p. 57); Agro-Fibers Inc. in Corcoran, Calif., a subsidiary of the McCarthy Farms Organization; and Natural Fibers of Louisiana, operated by H. Willett & Associates in Jeanerette, La. All of these organizations have found valuable uses for the core material. Therefore, the bark fiber can be made available as a supplementary raw material for pulp and paper mills at a reasonable price.

CONCLUSIONS. On a worldwide basis, the future use of nonwood plant fibers on a large scale is indeed a reality. For the medium- and long-term future, greater use of these raw materials in the U.S. will become a reality as well. With an annual availability of more than 100 million tons of cereal straw, 2.8 million tons of moist depithed bagasse, one million tons of seed-grass straw, and as much as 28 million tons of sorghum stalks, plus the exciting potential for kenaf and crotalaria, papermakers should certainly consider these alternatives at least as supplementary raw materials to woodpulp.

The advanced technology originally developed for bagasse is now being used in many countries for straw and other nonwood plant fibers, because the economics of using these raw materials has changed greatly since their use had to be abandoned years ago in the Midwest. There is no doubt that the economics of using these raw materials are already favorable in the U.S., especially in areas where pulpwood costs have escalated in recent years. ■

NOTE

ONLY THE FOLLOWING PAGES OF THIS PUBLICATION HAVE BEEN FILMED

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